

Spatial Distribution of Mercury Vapor in Homes in Brooklyn, New York

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ABSTRACT

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Elemental mercury is an important Persistent, Bioaccumulative and Toxic (PBT) pollutant. Over the years, many methods have been developed attempting to measure the extremely low levels of mercury typically found in the atmosphere. Airborne total mercury concentrations in places beyond the direct influence of point sources are usually in the range of 1-5 ng/m³, making it necessary to pre-concentrate the analyte, generally for periods of 6 or 24 hours. This is usually followed by subsequent analysis in a laboratory mainly by cold vapor atomic absorption spectrophotometry (CVAAS). The U.S. EPA's is interested in identifying as many sources of mercury emissions to the air as possible and to quantify these emissions where possible. This study uses a spectrometer to measure low levels of mercury in the air and this data is used to calculate exposure for adults and children.

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INTRODUCTION

Mercury has long been known as a human toxicant. Paracelsus reported on mercury poisoning among miners several centuries ago. It has also been associated in other occupational exposures such as “Mad Hatters” disease. Elemental mercury is a heavy, silvery liquid at room temperature and pressure. It is remarkably volatile for a heavy metal, with a vapor pressure of 0.002 mm Hg at 20°C. The vapor pressure is strongly dependent on temperature, and it vaporizes readily under ambient conditions. Most of the mercury encountered in the atmosphere is monatomic elemental mercury vapor.^{1,2} Because of its high volatility and toxicity, mercury should always be kept in sealed containers and handled in well-ventilated areas. It is surprisingly soluble in both polar and nonpolar liquids. Mercury can exist in three oxidation states: Hg⁰ (metallic), Hg²⁺ (mercurous) and Hg²⁺ (mercuric). The properties and behavior of mercury depend on the oxidation state.^{1,2}

Mercury has many uses including fluorescent lamps, wiring devices and switches (e.g., thermostats)

mercuric oxide batteries, navigational devices, instruments that measure temperature and pressure (thermometers, barometers, etc.), component of dental amalgams used in repairing dental caries (cavities), as a preservative to many pharmaceutical products, as a solvent for reactive and precious metals, nuclear reactors, an anti-fungal agent in wood processing, chlorine and caustic soda manufacturing and as a catalyst.² All these uses contribute to the ambient, and in some cases, the indoor air mercury levels.

Elemental mercury is a toxic substance that cause many serious health problems. These include neurotoxicity, learning disabilities in children, sleeplessness, acrodynia, lung disease and respiratory failure.^{3,4,5,6} Very young children and fetuses are most vulnerable.⁷ Exposure to elemental mercury can occur through the air, water, food (usually from contaminated fish) and direct contact (absorption through the skin). Human exposure to elemental mercury occurs primarily from breathing contaminated air. Recently, The Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Protection Agency (EPA) jointly issued a mercury alert to the general public.⁸

However, it is common knowledge that elemental mercury is used in ethnic folk medicine and for religious practices by some members of the Latin American and Caribbean communities.⁹ Elemental mercury is sold under the name “azogue,” “azoge” or “quicksilver” in stores (sometimes called Botanicas) which specialize in religious items used in Esperitismo (a spiritual belief system native to Puerto Rico), Santeria (a Cuban and Brazilian-based religion that venerates both African deities and Catholic saints) and voodoo. The use of mercury in religious practices is recommended in some Latin American and Caribbean communities by family members, spiritualists, card readers and santeros.

In these practices, mercury is sprinkled on the floor or carpet and in cars, burnt with candles, added to bath water, soap solution and perfume, or worn as an amulet containing mercury.⁹ Figure 1 lists the different uses. Sprinkling or accidentally spilling elemental mercury on clothes, furniture, carpet, floors, walls, in cars, the natural environment and even the human body will result in contamination. Elemental mercury and its vapor are extremely difficult to remove from skin, clothes, furniture, carpet, floors and walls. It accumulates in electronic equipment such as computers where it vaporizes and condenses as the instrument is turned on and off in an endless cycle depending on the temperature. The use of elemental mercury in homes and apartments pose a health risk to anyone who spends time there. It is important to note here that exposure to mercury is not just limited to those who use it in religious practices and their families, but also to visitors to the home of mercury users, neighbors and passengers in the car of a user. Additionally, since some people use mercury frequently and the residence life of mercury in indoor air is estimated to be much longer than

one year, therefore when that mercury user vacates the property, the new occupants are unwittingly exposed to mercury for many months.

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RESEARCH DESIGN

In this project a Lumex RA-915+ Mercury Analyzer, based on atomic absorption spectrometry, with Zeeman polarization background correction was used to measure ambient and indoor mercury vapor concentrations in 23 homes in Brooklyn, New York. For dwellings, measurements were performed at the breathing zone of infants, toddlers and adults (6", 2', and 5', respectively) in living rooms bedrooms and basements. The Lumex RA-915+ permits continuous, real-time monitoring and data logging of mercury levels.

The following formula was used to calculate the dose for adults and children:

Dose (ng/kg/day)= Concentration x breathing rate x 1/bodyweight

x Absorption rate x I/O x duration of exposure

where,

I/O = indoor/outdoor ratio

bodyweight = 70kg (adult) and 30kg (child)

breathing rate = 18 m³/24hr/day (adult)

= 12 m³/24hr/day (child)

Absorption rate = 80%

Duration of Exposure = 12 hrs

RESULTS

Measured mercury vapor level ranges from 4 - 112 ng/m³ (mean: 25 ng/m³) for indoor air and N.D. (none detect) - 11 ng/m³ (mean: 5 ng/m³) for ambient air (Figure 1). The instrument has a Detection Limit of 0.2 ng/m³. Our reference analytical technique for mercury vapor is the NIOSH 6009 method.

The exposure dose are represented in Figure 2. For a child, the range was from 3.2 to 89.6 ng/kg/day (mean=20 ng/kg/day). For the adult, it ranged from 2.3 to 53 ng/kg/day (mean= 12 ng/kg/day)..

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DISCUSSION

Based on a previous study done last year, it was expected for there to be variation with respect to height above the ground. However, this present study showed little or no variation with respect to spatial distribution. This was probably due to the complete mixing of the indoor air during the summer months.

On average, the indoor level was five times the amount found in the outdoor air. Table 1 shows some possible sources of mercury. The difference between indoor and outdoor concentrations can be explained by

the fact that the confines of the building traps the mercury inside; while a higher volume of air outside causes mixing and dilution and dispersion – atmospheric removal mechanisms. These are absent or insignificant for indoor.

The highest exposure dose was 89.6 ng/kg/day. The Agency for Toxic Substances and Disease Registry had no standards set for the breathing in of mercury vapor.

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FUTURE STUDIES

Winter levels should be measured to see if there is any seasonal variation that may be due, in part, to temperature or poor circulation of air in the sealed dwellings.

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Table 1 Source contribution to mercury in indoor and ambient air

Ambient	Indoor
Municipal waste incinerator	tobacco smoke
Medical waste incinerators	electric switches
Electric utility boilers (Coal, gas,oil)	broken thermometers
Chloralkali factories	dental amalgams
Non-ferrous metal smelting	old interior latex paint
Area sources (e.g. dental amalgams, fluorescent light fixtures)	Cultural uses (selected communities) Residential boilers